REMARKS

The present patent application now comprises fifty-four (54) claims, numbered 1 to 15, 17 to 37, 39, 40, 44, 45, 49, 50 and 53 to 64.

Claims 4, 5, 10 to 14, 23 to 27, 35 and 36 have been previously withdrawn. Claims 16, 41, 42, 46, 47, 51 and 52 have been previously cancelled.

Claims 1, 22 and 32 have been amended. Support for these amendments may be found, *inter alia*, on page 15, lines 9 and 10; page 23, lines 7-9; and page 29, lines 1 and 2 of the specification as originally filed. Claims 39, 44 and 49 have also been amended to change their dependency.

Claims 38, 43 and 48 have been cancelled.

New claims 56-64 have been added. Support for these new claims may be found, *inter alia*, on page 15, lines 6-9; page 18, lines 12 an 13; page 23, lines 19-23; and page 24, lines 18 and 19 of the specification as originally filed

No new matter has been added to the present patent application by the present response.

1. Rejection of Claims 1-3, 15-19, 22, 28-34 and 37 under 35 USC 102

On pages 2-4 of the Final Office Action, the Examiner rejected claims 1-3, 15-19, 22, 28-34 and 37 under 35 USC 103(a) as being unpatentable over U.S. Patent 6,407,855 to MacCormack *et al.* (hereinafter referred to as "MacCormack") in view of U.S. Patent 5,323,404 to Grubb (hereinafter referred to as "Grubb"). The Examiner also appears to have rejected claims 38, 39, 43, 44, 48 and 49.

As discussed below, the Applicants respectfully submit that claims 1-3, 15, 17-19, 22, 28-34, 37, 39, 44 and 49, as amended, are in allowable form and respectfully request the Examiner to withdraw the rejection of these claims. For their part, claims 38, 43 and 48 have been cancelled.

Independent claims 1, 22 and 32

Claims 1, 22 and 32 are reproduced below with certain elements being emphasized:

1. A multi-wavelength laser source comprising:
    a) an input for receiving an energy signal;
    b) a gain section in communication with said input, said gain section including a **homogeneously broadened gain medium** having a superstructure grating, said superstructure grating forming a plurality of cavities that are distributed in said homogeneously broadened gain medium such that different resonant wavelengths resonate in respective ones of said cavities when the energy signal is applied to said gain section, **at least two of said cavities being separated from one another**, said gain section generating a multi-wavelength laser signal when the energy signal is applied to the gain section; and
    c) an output for emitting the multi-wavelength laser signal.

22. A method suitable for generating a multi-wavelength laser signal, said method comprising:
    a) receiving an energy signal;
    b) providing a gain section including a **homogeneously broadened gain medium** having a superstructure grating, said superstructure grating forming a plurality of cavities that are distributed in said homogeneously broadened gain medium such that different resonant wavelengths resonate in respective ones of said cavities when the energy signal is applied to said gain section, **at least two of said cavities being separated from one another**; and
    c) applying the energy signal to said gain section to generate a multi-wavelength laser signal.

32. A multi-wavelength laser source comprising:
    a) a pump laser unit adapted for generating an energy signal;
    b) a gain section including a **homogeneously broadened gain medium** having a superstructure grating, said superstructure grating forming a plurality of cavities that are distributed in said homogeneously broadened gain medium such that different resonant wavelengths resonate in respective ones of said cavities when the energy signal is applied to said gain section, **at least two of said cavities being separated from one another**, the pump laser unit being adapted for applying the energy signal to said gain section to cause a multi-wavelength laser signal to be generated; and
    c) an output for emitting the multi-wavelength laser signal.

As conceded by the Examiner on page 2 of the Final Office Action, MacCormack fails to disclose a superstructure grating forming a plurality of cavities where at least two of the cavities are separated from one another. To address this deficiency of MacCormack, the Examiner applies Grubb and contends that Grubb discloses a multi-wavelength laser source where cavities formed by gratings are separated from one another.

Claims 1, 22 and 32 have been amended to incorporate an element previously claimed in claims 38, 43 and 48, which respectively depended on claims 1, 22 and 32 prior to being cancelled. Specifically, claims 1, 22 and 32 now specify that the gain medium, which has the claimed superstructure grating with at least two cavities separated from one another, is a homogeneously broadened gain medium.

As will now be discussed, MacCormack and Grubb neither teach nor suggest using a homogeneously broadened gain medium and, therefore, fail to teach or suggest the claimed homogeneously broadened gain medium having a superstructure grating forming a plurality of cavities in which resonate different resonant wavelengths when an energy signal is applied, where at least two of the cavities are separated from one another.

– MacCormack –

In rejecting claims 38, 43 and 48, the Examiner contends that MacCormack teaches a homogeneously broadened gain medium by referring to a passage of MacCormack (col. 5, lines 20-24) that recites a "single mode fiber" and by stating that "fiber based gain media are homogeneously broadened".

With all due respect, the Applicants strongly and respectfully disagree with the Examiner and submit that MacCormack does not teach or suggest a homogeneously broadened gain medium. Rather, MacCormack teaches using a Raman gain medium (see, *inter alia*, col. 1, lines 17-25 and 57-61; col. 2, lines 1-3 and 28-40; col. 3, lines 28-30; col. 5, lines 6-34

(which includes the very passage cited by the Examiner); col. 6, lines 27-50; col. 7, lines 58-61; col. 8, lines 1-3; col. 10, lines 1-4 and 22-28; and col. 11, lines 14-17 and 39-41).

As discussed on pages 9 and 10 of the response to Office Action filed on June 27, 2006, a Raman gain medium is based on stimulated Raman scattering and is thus fundamentally different from a homogeneously broadened gain medium, which is based on excitation of carriers to an upper energy level through absorption of pump energy.

More specifically, stimulated scattering laser systems like those of MacCormack, which are Raman-based, have stimulated emission that is shifted by a specific amount of energy with respect to the optical pump, the shift being determined by the material of the active medium. Thus, pumps of virtually any wavelength can be used and the lasing signal is generated at wavelengths shifted by an amount specific to the used material. As such, the pumping process characteristic of scattering-based (i.e., Raman) gain is central to MacCormack, as the pump energy generates the first signal, which then acts as a pump for the second signal, which in turn acts as a pump for the third signal, and so on, as discussed in MacCormack (e.g., col. 5, lines 10-19).

In a fundamentally different way, a homogeneously broadened gain medium, such as glass doped with rare earth ions, relies on excitation of carriers to an upper energy level through absorption of pump energy in order to achieve laser action. In particular, in a homogeneously broadened gain medium, the choice of the pump wavelength is *a priori* constrained by the difference in the existing energy levels (e.g., the existing electron energy levels of the rare earth ions in a case where the homogeneously broadened gain medium is glass doped with rare earth ions). In addition, this type of gain medium is characterized by an optical gain behaviour that usually prevents laser emission of multiple wavelength bands simultaneously in continuous wave (CV) regime at room temperature. This so-called homogeneously broadened gain behaviour results from gain competition between the laser lines. Specifically, the signal at the wavelength with the highest net gain will deplete the pump energy and will preclude other wavelengths from reaching laser oscillation. Therefore, when used to make lasers, a homogeneously broadened gain medium has the unfortunate property that it usually

emits over only one narrow wavelength band, because of gain competition between the laser lines. As such, homogeneously broadened gain media typically require specific techniques to overcome the gain competition which is intrinsic to this type of gain medium[1].

Homogeneous and inhomogeneous broadening are mostly used to describe optical gain behaviour related to resonant electron transition in atoms or ions. However, it is well established that Raman gain is similar to an inhomogeneously broadened gain medium. This is evidenced by the following references (copies of which are annexed hereto), which discuss differences between a homogeneously broadened gain medium such as that used in an erbium-doped fiber laser and an inhomogeneously broadened gain medium used in a Raman fiber laser:

- C.J.S. de Matos *et al.*, "Multi-wavelength, continuous wave fibre Raman ring laser operation at 1.55 μm," Electronics Letters, vol. 37, no.13, (2001), pp 825-826. For example, paragraph 2, lines 1-3 states that: "The inhomogeneously broadened gain of stimulated Raman scattering (SRS) provides an alternative approach to designing a room temperature WDM source" (emphasis added).

- Y.-G. Han *et al.*, "Tunable multi-wavelength Raman fibre laser on fibre Bragg grating cavity with PMF Lyot-Sagnac filter," Electronics Letters, vol. 40, no.23, (2004), pp 1475-1476. For example, paragraph 1, lines 16-18 states that: "Since Raman fibre lasers have inhomogeneous broadening characteristics, they can operate stably at room temperatures" (emphasis added).

[1] The Applicants do not contend to have invented homogeneously broadened gain media. Rather, by virtue of providing a homogeneously broadened gain medium with the claimed superstructure grating, the Applicants bring a solution to the problem of gain competition between laser lines that is traditionally associated with homogeneously broadened gain media and that results in such gain media usually emitting over only one narrow wavelength band. In particular, the inventors have made the unexpected discovery that by using the claimed superstructure grating on a homogeneously broadened gain medium, cross-gain saturation at room temperature between laser wavelengths can be overcome. The superstructure grating creates a distributed Fabry-Perot-like structure that causes generation of a multi-wavelength laser signal when an energy signal is applied to the gain section. This result is different from what is traditionally achieved by use of a homogeneously broadened gain medium.

- Z. Wang *et al.*, "Multiwavelength generation in a Raman fiber laser with sampled Bragg grating," Photonics Technology Letters, vol. 17, no.10, (2005), pp 2044-2046. For example, paragraph 1, lines 11-13 states that: "Recently, multiwavelength Raman fiber laser has been investigated for the simpler operation at room temperature because of its inhomogeneous broadening characteristics" (emphasis added).

Clearly, therefore, a Raman gain medium is not a homogeneously broadened gain medium. As such, it is apparent that MacCormack, which teaches using a Raman gain medium, fails to teach or suggest using a homogeneously broadened gain medium.

Notwithstanding MacCormack's failure to teach or suggest using a homogeneously broadened gain medium, MacCormack's grating configuration would not readily allow lasing of many wavelengths in a homogeneously broadened gain medium. Specifically, all cavities of MacCormack's gain medium are *overlapping* (see Figures 1 to 5, 11 and 12 and their description (e.g., col. 5, lines 31 to 49) where all cavities, which are formed by pairs of gratings (e.g., 12-12, 14-14, 16-16, etc.), are overlapping). As homogeneously broadened gain media usually emit over only one narrow wavelength band because of gain competition between laser lines, a hypothetical application of MacCormack's cavity configuration to a homogeneously broadened gain medium would cause gain competition between laser lines (due to different wavelengths resonating in overlapping portions of MacCormack's gain medium) and thus would not readily allow lasing of many wavelengths in the homogeneously broadened gain medium. In fact, owing to its cavity configuration which would induce gain competition between laser lines in overlapping portions of its gain medium, MacCormack *teaches away* from using a homogeneously broadened gain medium since this would hinder generation of multiple laser wavelengths.

Accordingly, it is respectfully submitted that MacCormack neither teaches nor suggests (and in fact teaches away from) the claimed homogeneously broadened gain medium having a superstructure grating forming a plurality of cavities where at least two of the cavities are separated from one another.

– Grubb –

Grubb describes an optical fiber non-linear interaction (NLI) laser, which may be a Raman laser, a Brillouin laser, or a four-photon mixing laser (see, *inter alia*, col. 1, lines 9-11 and 14-18; col. 2, lines 35-38; col. 3, line 10 to col. 4, line 30; col. 4, lines 33-48; and col. 5, lines 13-14).

There is no teaching or suggestion in Grubb of using a homogeneously broadened gain medium. Rather, Grubb teaches using a gain medium that achieves laser action via a non-linear effect, i.e., Raman scattering, Brillouin scattering, or four-photon mixing, in the gain medium.

As discussed above in respect of MacCormack, a Raman gain medium is fundamentally different from a homogeneously broadened gain medium. In a similar manner, gain media based on other non-linear effects, such as Brillouin scattering or four-photon mixing, are also fundamentally different from homogeneously broadened gain media, which rely on excitation of carriers to an upper energy level through absorption of pump energy in order to achieve a laser action.

As discussed above, homogeneous and inhomogeneous broadening gain characteristics are mostly used to describe optical gain behaviour related to resonant electron transition in atoms or ions. However, it is well established that, like Raman gain media, other non-linear effect gain media such as gain media based on Brillouin scattering or four-photon mixing mainly have an inhomogeneously broadened gain behaviour. This is evidenced by the following references (copies of which are annexed hereto):

- V. I. Kovalev *et al.*, "Observation of inhomogeneous spectral broadening of stimulated Brillouin scattering in an optical fiber," Physical Review Letters, vol. 85, no.9, (2000), pp 1879-1882. For example, paragraph 2, lines 1-3 states that: "In this letter we report

experimental results that show the [stimulated Brillouin scattering] spectrum in single-mode optical fiber is inhomogeneous, exhibiting characteristic spectral hole burning under cw monochromatic laser excitation" (emphasis added).

- V. I. Kovalev *et al.*, "Waveguide-induced inhomogeneous spectral broadening of stimulated Brillouin scattering in optical fiber," Optics Letters, vol. 27, no.22, (2002), pp 2022-2024. For example, paragraph 1, lines 12-16 states that: "Recently we reported observation of inhomogeneous broadening of the Brillouin spectrum and spectral hole burning in this spectrum, the features of which are independent of the type of fiber or its length" (emphasis added).

- A. Mocofanescu *et al.*, "Recent studies of CW stimulated Brillouin scattering in single mode and multimode optical fibers," Conference on Lasers & Electro-Optics,paper CMCC6, (2005), pp 520-522. For example, paragraph 3, line 1 states that: "The [stimulated Brillouin scattering] gain coefficient g_i for inhomogeneous broadening due to waveguiding in an optical fiber is derived as [equation 2]" (emphasis added).

- S. A. Babin *et al.*, "Four-wave-mixing-induced turbulent spectral broadening in long Raman fiber laser," Journal of the Optical Society of America B, vol. 24, no.8, (2007), pp 1729-1738. For example, paragraph 1, lines 8-9 of section 5 states that: "Usually it is deemed that this possibility exists due to the inhomogeneous nature of the Raman gain spectrum"; and paragraph 3, lines 1-3 of section 5 states that: "In the present paper, we have proved experimentally and theoretically that inhomogeneous mechanism are indeed based on [four-wave-mixing]" (emphasis added).

Therefore, since Grubb teaches gain media based on non-linear effects (i.e., Raman scattering, Brillouin scattering, or four-photon mixing) that are not homogeneously broadened gain media, it is ample clear that Grubb (like MacCormack) does not teach or suggest using a homogeneously broadened gain medium.

Accordingly, it is respectfully submitted that Grubb (like MacCormack) neither teaches nor suggest the claimed <u>homogeneously broadened gain medium</u> having a superstructure grating forming a plurality of cavities where <u>at least two of the cavities are separated from one another</u>.

In light of the foregoing, it is respectfully submitted that MacCormack and Grubb, separately or in combination, fail to teach or suggest all of the elements of each of claims 1, 22 and 32. As such, the cited art's failure to teach or suggest all of the claim elements precludes a finding of obviousness in respect of claims 1, 22 and 32. Notwithstanding this, since MacCormack teaches away from the claimed invention, combining MacCormack with any reference (including Grubb) cannot support a finding of obviousness in respect of claims 1, 22 and 32. For these reasons, the Examiner is respectfully requested to withdraw the rejection of claims 1, 22 and 32, which are believed to be allowable.

<u>Dependent claims 2, 3, 15, 17-19, 28-31, 33, 34, 37, 39, 44 and 49</u>

Each of claims 2, 3, 15, 17-19, 28-31, 33, 34, 37, 39, 44 and 49 depends on one of claims 1, 22 and 32 and thus incorporates by reference all of the elements of that base claim. Thus, for the same reasons as those set forth above in respect of claims 1, 22 and 32, the Examiner is respectfully requested to withdrawn the rejection of claims 2, 3, 15, 17-19, 28-31, 33, 34, 37, 39, 44 and 49, which are believed to be in allowable form.

2. Rejection of Claims 6-9, 20 and 21 under 35 USC 103

On pages 4 and 5 of the Final Office Action, the Examiner rejected claims 6-9, 20 and 21 under 35 USC 103(a) as being unpatentable over MacCormack in view of U.S. Patent Application Publication 2004/0037505 by Morin (hereinafter referred to as "Morin"). As discussed below, it is respectfully submitted that claims 6-9, 20 and 21 are in allowable form.

Specifically, each of claims 6-9, 20 and 21 depends on claim 1 and thus incorporates by reference all of the elements of claim 1, including that shown above to be absent from MacCormack and Grubb, namely, a homogeneously broadened gain medium having a superstructure grating forming a plurality of cavities where at least two of the cavities are separated from one another.

It is respectfully submitted that this element, which is absent from MacCormack and Grubb, is also absent from Morin. Indeed, Morin discloses and claims a certain type of Fiber Bragg Grating Gires-Tournois interferometer for *chromatic dispersion compensation* in a passive optical fiber, i.e., in a fiber without optical gain (parag. 16, 18 to 21, 37 and 38). That is, Morin's passive optical fiber does not form a gain medium, let alone a homogeneously broadened gain medium, and is not used for *laser generation*[2].

Furthermore, while Morin's interferometer can be provided with gratings that define multiple cavities, the absence of a gain medium makes it impossible to effect any type of distribution of cavities in a gain medium, let alone one where at least two of the cavities are separated from one another.

Accordingly, it is respectfully submitted that at least one element of claims 6-9, 20 and 21 (by virtue of their dependency on claim 1) is neither taught nor suggested by MacCormack, Grubb and Morin, whether taken separately or in combination. As such, the cited art's failure to teach or suggest all of the claim elements precludes a finding of obviousness in respect of claims 6-9, 20 and 21. The Examiner is therefore respectfully requested to withdraw the rejection of claims 6-9, 20 and 21, which are believed to be allowable.

[2] Notwithstanding that Morin's interferometer is specifically designed for *chromatic dispersion compensation* and is in no way intended to be used for *laser generation*, Morin's interferometer actually renders laser action impossible. Indeed, Morin's interferometer requires a strong back reflector combined with one or more much weaker input reflectors to achieve its desired dispersion compensation effect (parag. 37, lines 15 to 30 and parag. 38, lines 16 to 21). These one or more weaker input reflectors render laser action impossible. Thus, not only is Morin clearly not concerned with laser generation, Morin actually *teaches away* from application of its grating structure for laser generation purposes. As such, combining Morin with any reference (including MacCormack) cannot support a contention of obviousness.

3. Rejection of Claims 40, 45 and 50 under 35 USC 103

On page 5 of the Final Office Action, the Examiner rejected claims 40, 45 and 50 under 35 USC 103(a) as being unpatentable over MacCormack in view of Grubb.

Each of claims 40, 45 and 50 depends on one of claims 1, 22 and 32 and thus incorporates by reference all of the elements of that base claim. Thus, for the same reasons as those set forth above in respect of claims 1, 22 and 32, MacCormack and Grubb fail to teach or suggest all of the elements of each of claims 40, 45 and 50. As such, the cited art's failure to teach or suggest all of the claim elements precludes a finding of obviousness in respect of claims 40, 45 and 50. Notwithstanding this, since MacCormack teaches away from the claimed invention, combining MacCormack with any reference (including Grubb) cannot support a finding of obviousness in respect of claims 40, 45 and 50. For these reasons, the Examiner is respectfully requested to withdraw the rejection of claims 40, 45 and 50, which are believed to be allowable.

4. Patentability of New Dependent Claims 56-64

New dependent claims 56-64 are believed to be allowable form, for the following reasons.

<u>Dependent claims 56, 59 and 62</u>

For ease of reference, these claims are reproduced below, with certain portions being emphasized:

> 56. A multi-wavelength laser source as defined in claim 1, wherein said homogeneously broadened gain medium is a **rare-earth-doped** gain medium.
>
> 59. A method as defined in claim 22, wherein the homogeneously broadened gain medium is a **rare-earth-doped** gain medium.
>
> 62. A multi-wavelength laser source as defined in claim 32, wherein said homogeneously broadened gain medium is a **rare-earth-doped** gain medium.

Each of claims 56, 59 and 62 depends on one of claims 1, 22 and 32 and thus incorporates by reference all of the elements of that base claim. Thus, for the same reasons as those set forth above in respect of claims 1, 22 and 32, MacCormack and Grubb fail to teach or suggest all of the elements of each of claims 56, 59 and 62. As such, the cited art's failure to teach or suggest all of the claim elements precludes a finding of obviousness in respect of claims 56, 59 and 62. Notwithstanding this, since MacCormack teaches away from the claimed invention, combining MacCormack with any reference (including Grubb) cannot support a finding of obviousness in respect of claims 56, 59 and 62. For these reasons, claims 56, 59 and 62 are believed to be allowable.

In addition, each of claims 56, 59 and 62 specify that the homogeneously broadened gain medium is a <u>rare-earth-doped</u> gain medium, i.e., a gain medium doped with one or more rare-earth elements.

Neither MacCormack nor Grubb teaches or suggests a <u>rare-earth-doped</u> gain medium. Rather, MacCormack describes a Raman medium with a high content of germanium or phosphorous (col. 5, lines 21-23). Similarly, Grubb also describes a gain medium containing germanium or phosphorous (col. 5, lines 1-12). In fact, Grubb emphasises that his laser does not require the presence of a special dopant in his gain medium (col. 4, lines 52-55). Clearly, therefore, neither MacCormack nor Grubb teaches or suggests a <u>rare-earth-doped</u> gain medium.

Accordingly, in addition to being allowable in view of their dependency on claims 1, 22 and 32, claims 56, 59 and 62 are believed to be allowable for the above additional reasons.

<u>Dependent claims 57, 60 and 63</u>

For ease of reference, these claims are reproduced below, with certain portions being emphasized:

> 57. A multi-wavelength laser source as defined in claim 1, wherein each of said cavities has a length in a **millimeter** order of magnitude.

> 60. A method as defined in claim 22, wherein each of the cavities has a length in a **millimeter** order of magnitude.
>
> 63. A multi-wavelength laser source as defined in claim 32, wherein each of said cavities has a length in a **millimeter** order of magnitude.

Each of claims 57, 60 and 63 depends on one of claims 1, 22 and 32 and thus incorporates by reference all of the elements of that base claim. Thus, for the same reasons as those set forth above in respect of claims 1, 22 and 32, MacCormack and Grubb fail to teach or suggest all of the elements of each of claims 57, 60 and 63. As such, the cited art's failure to teach or suggest all of the claim elements precludes a finding of obviousness in respect of claims 57, 60 and 63. Notwithstanding this, since MacCormack teaches away from the claimed invention, combining MacCormack with any reference (including Grubb) cannot support a finding of obviousness in respect of claims 57, 60 and 63. For these reasons, claims 57, 60 and 63 are believed to be allowable.

In addition, each of claims 57, 60 and 63 specify that each cavity has a length in a <u>millimeter</u> order of magnitude.

Neither MacCormack nor Grubb teaches or suggests cavities each having a length in a <u>millimeter</u> order of magnitude. Rather, both MacCormack and Grubb, which use non-linear effects (e.g., Raman effects) in their gain medium, *require* long cavity lengths of <u>tens of centimeters to hundreds of meters</u> in order to achieve laser action. More particularly, MacCormack describes cavity lengths <u>greater than 20 cm</u> (col. 3, lines 48-50), while Grubb describes cavity lengths <u>on the order of 1 km</u> (col. 5, lines 39 and 40). Clearly, therefore,

neither MacCormack nor Grubb teaches or suggests cavities each having a length in a millimeter order of magnitude[3].

Since mode spacing is inversely proportional to cavity length, the long cavity lengths required by MacCormack and Grubb result in emitted wavelength bands containing a very high number of modes and, thus, noisy outputs. In contrast, the claimed small cavity length (i.e., in a millimeter order of magnitude) promotes high purity output with single-mode laser lines (e.g., producing linewidths around 100 kHz, as mentioned on page 25, lines 5-7 of the specification as originally filed).

Accordingly, in addition to being allowable in view of their dependency on claims 1, 22 and 32, claims 57, 60 and 63 are believed to be allowable for the above additional reasons.

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[3] As further evidence that gain media based on non-linear effects, such as Raman scattering, Brillouin scattering, or four-photon mixing, require long cavity lengths in order to achieve laser action, the Examiner can refer to the previously mentioned references:

- C.J.S. de Matos *et al.*, "Multi-wavelength, continuous wave fibre Raman ring laser operation at 1.55 µm,", which states, for example, at paragraph 3, lines 2-6 that: "The Raman gain medium was 7 km of dispersion compensation fibre (DCF) pumped at 1455 nm by a fibre Raman pump laser providing up to 1.3 W of power, with peak Raman gain at 1555 nm" (emphasis added);
- Y.-G. Han *et al.*, "Tunable multi-wavelength Raman fibre laser on fibre Bragg grating cavity with PMF Lyot-Sagnac filter,", which states, for example, at paragraph 3, lines 12-15 that: "After combining four pump sources (λp=1425, 1435, 1455, 1465 nm) with a passive 14XX/C-band WDM coupler, a total pump power of 900 mW could be launched into 25 km standard singlemode fibre (SMF) with 0.2dB/km attenuation" (emphasis added);
- Z. Wang *et al.*, "Multiwavelength generation in a Raman fiber laser with sampled Bragg grating", which states, for example, at paragraph 1, lines 2-5 of section III that: "The laser consists of a ring cavity composed with a WDM coupler, 5-km dispersion compensating fiber (DCF) used as Raman gain fiber, an SBG employed as the multichannel filter, a circulator, and a 3-dB coupler" (emphasis added);
- V. I. Kovalev *et al.*, "Observation of inhomogeneous spectral broadening of stimulated Brillouin scattering in an optical fiber,", which states, for example, at paragraph 3, lines 16-18 that: "Three single-mode fibers and one two-mode fiber of telecom grade with length from ~100 to ~650 m were investigated" (emphasis added);
- V. I. Kovalev *et al.*, "Waveguide-induced inhomogeneous spectral broadening of stimulated Brillouin scattering in optical fiber", which states, for example, at Table 1 (Characteristics of the fibers tested): Fiber SM1322 L=650 m, fiber SM1000 L=98 m, fiber ND-716 L=236 m, fiber MM50/125 L=3600 m and fiber FS-SC5924 L=200 m (emphasis added); and
- S. A. Babin *et al.*, "Four-wave-mixing-induced turbulent spectral broadening in long Raman fiber laser", which states, for example, at paragraph 1, lines 10-12 of section 2 that: "In the high-Q [Raman fiber laser] cavity having length L=370 m and formed by two fiber Bragg gratings with peak reflectivities of R1≈R2>99%" (emphasis added).

Dependent claims 58, 61 and 64

For ease of reference, these claims are reproduced below, with certain portions being emphasized:

> 58. A multi-wavelength laser source as defined in claim 1, wherein said homogeneously broadened gain medium has a length, the multi-wavelength laser signal is characterized by a number of laser wavelengths, and a ratio of the number of laser wavelengths to the length of said gain medium is **at least 1 laser wavelength per cm of length of said gain medium**.
>
> 61. A method as defined in claim 22, wherein the homogeneously broadened gain medium has a length, the multi-wavelength laser signal is characterized by a number of laser wavelengths, and a ratio of the number of laser wavelengths to the length of the gain medium is **at least 1 laser wavelength per cm of length of the gain medium**.
>
> 64. A multi-wavelength laser source as defined in claim 32, wherein said homogeneously broadened gain medium has a length, the multi-wavelength laser signal is characterized by a number of laser wavelengths, and a ratio of the number of laser wavelengths to the length of said gain medium is **at least 1 laser wavelength per cm of length of said gain medium**.

Each of claims 58, 61 and 64 depends on one of claims 1, 22 and 32 and thus incorporates by reference all of the elements of that base claim. Thus, for the same reasons as those set forth above in respect of claims 1, 22 and 32, MacCormack and Grubb fail to teach or suggest all of the elements of each of claims 58, 61 and 64. As such, the cited art's failure to teach or suggest all of the claim elements precludes a finding of obviousness in respect of claims 58, 61 and 64. Notwithstanding this, since MacCormack teaches away from the claimed invention, combining MacCormack with any reference (including Grubb) cannot support a finding of obviousness in respect of claims 58, 61 and 64. For these reasons, claims 58, 61 and 64 are believed to be allowable.

In addition, each of claims 58, 61 and 64 specify that a ratio of the number of laser wavelengths to the length of the gain medium is <u>at least 1 laser wavelength per cm of length of the gain medium</u>. Support for this can be found, *inter alia*, on page 23, lines 19-23 and page 24, lines 19-22 of the specification as originally filed. Specifically, in the disclosed

example, a gain medium, i.e., a deuterium loaded Er^{3+}-Yb^{3+} optical fiber, has a length of 8 cm and, in one case, 8 laser wavelengths were obtained (giving a ratio of 8/8 = 1 laser wavelength per cm of length of the gain medium) while, in another case, 15 laser wavelengths were obtained (giving a ratio of 15/8 = 1.875 laser wavelength per cm of length of the gain medium), thus providing support for the claimed ratio of at least 1 laser wavelength per cm of length of the gain medium.

Neither MacCormack nor Grubb teaches or suggests generation of a multi-wavelength laser signal where a ratio of the number of laser wavelengths to the length of the gain medium is at least 1 laser wavelength per cm of length of the gain medium. Rather, as described above, MacCormack and Grubb, which use non-linear effects (e.g., Raman effects) in their gain medium, *require* long cavity lengths of tens of centimeters to hundreds of meters in order to achieve laser action. This implies that gain media used by MacCormack and Grubb, in which these long cavities are formed, are also very long, i.e., at least tens of centimeters to hundreds of meters in length. As MacCormack's and Grubb's lasers produce a few (e.g., up to six) laser wavelengths (see col. 5, line 57 to col. 6, line 4 of MacCormack; and col. 4, lines 36 and 37 and Figure 3 of Grubb), it is clear that MacCormack and Grubb are far from teaching or suggesting generation of a multi-wavelength laser signal where a ratio of the number of laser wavelengths to the length of the gain medium is at least 1 laser wavelength per cm of length of the gain medium.

Accordingly, in addition to being allowable in view of their dependency on claims 1, 22 and 32, claims 58, 61 and 64 are believed to be allowable for the above additional reasons.

CONCLUSION

Claims 1 to 3, 6 to 9, 15, 17 to 22, 28 to 34, 37, 39, 40, 44, 45, 49, 50 and 53 to 64 are believed to be in allowable form. Favorable reconsideration is requested. In addition, rejoinder of withdrawn claims 4, 5, 10 to 14, 35 and 36, which are also believed to be in allowable form, is respectfully requested upon allowance of the generic claims presently in the application. Early allowance of the application is earnestly solicited.

If the claims of the application are not considered to be in full condition for allowance, for any reason, the Applicants respectfully request the constructive assistance and suggestions of the Examiner in drafting one or more acceptable claims pursuant to MPEP 707.07(j) or in making constructive suggestions pursuant to MPEP 706.03 so that the application can be placed in allowable condition as soon as possible and without the need for further proceedings.

Respectfully submitted,

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